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EMPTY PEA PODS BASED SILAGE MAKING TECHNOLOGY: AN ALTERNATIVE SOURCE OF QUALITY FODDER IN UTTARAKHAND

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SUMMARY

To evaluate the proper combination of empty pea pods (EPP) based mixed fodder along with the available crop residues (bagasse and wheat straw) for silage making, a trial was conducted during *Rabi* season, 2025 at a cattle feed plant (CFP), Rudrapur, Uttarakhand, India. In total 7 treatment combinations were made to find out best combinations to get good to satisfactory silage quality. It was found that good quality silage can be made by using empty pea pods (EPP) in combination with wheat straw, sugarcane bagasse and dry jaggery in the ratio of (70:29:1) in form of silage bales during winter season. After completion of 45 days of ensiling period, amongst different silage treatments T1, T2, T3, T4, T5 & T6 treatments, silage pH was recorded 3.97, 3.96, 4.0, 4.5, 4.39 and 4.25; moisture content (%) was recorded 65.9, 68.5, 71.2, 68.13, 75.68 and 76.55; crude protein was recorded 7.68, 10.39, 11.02, 7.17, 9.23 and 10.08; ether extract was recorded 1.1, 1.08, 1.0,1.1, 1.0 and 1.0; crude fibre was recorded 48.23, 44.17, 43.87 59.85, 61.0 and 51.23; acid insoluble ash was recorded 3.11, 3.0, 2.92,2.04, 1.52 and 1.15, respectively. Based on total marks scored in different silage treatments as per the data recording for proximate parameters and texture, colour and aroma, overall silage quality was judged good in case of T1, satisfactory in case of T2, T3, T5 and T6 and average in case of T4 and T7 treatment combinations.

Key words: Silage, pea pods, pH, crop residues, bagasse, wheat straw and proximate parameters

Uttarakhand the 27th state of India lies between 28° 44' & 31° 28' N Latitude and 77° 35' & 81° 01' East Longitude. Uttarakhand is characterized by diverse geographical features ranging from snow-capped mountain peaks in the North to sub-tropical forests in the South. Out of total fodder produced in the state 70% of fodder supply is attributed to forest (42% grasses and 28% tree leaves) and rest from crop residues indicating direct dependency for fodder on forests, pastures and other common property resources. In Uttarakhand, farmers cultivate different seasonal fodder crops *viz*. sorghum, bajra, maize, cowpea, berseem, forage brassica, oats, hybrid bajra Napier grass, setaria grass etc. in 2-3% of the cultivated area. It has been estimated that there is a deficiency of about 33.83% green fodder and about 17.48% dry fodder in the state. Out of 13 districts, 11 districts face fodder deficit (ICAR-IGFRI, 2022). Due to pressure on land to produce more food crops and small holdings with farmers, there is hardly any scope for increasing area under fodder cultivation in Uttarakhand. However, due to abundant availability of crop residues/bio-waste from cereals crops and agro-industry, there is a scope to judiciously utilise them for fodder purpose by adopting suitable technologies.

In Udham Singh Nagar and its neighbouring districts of Uttarakhand, many factories are involved in processing of garden pea (*Pisum sativum*) and sugarcane (*Saccharum officinarum)* crops to produce frozen peas grains and sugar/molasses, respectively. In sugar factories, bagasse, the fibrous residues left after sugarcane stalks are crushed to extract juice, is primarily used as a fuel source to generate steam and electricity for self-utilisation and also sold to papermills for paper and board production. After the shelling of green peas pods the leftover material is called empty pea pods (EPP) constituting about 55% of intact pea pods. However, due to a lack of awareness and locally available waste processing facilities, the empty pea pods have traditionally been relegated to the status of under-utilized waste by-products. Wadha *et al.* (2021) reported that feeding of EPP and wheat straw silage based total mixed ration can be safely incorporated in the ration of ruminants. Fatima *et al.* (2024) have reported that EPP contains good quantity of nutrients for diverse industrial utilisation. Lata and Mondal

(2024) reported that EPP contain 19.8% crude protein and 1.0% ether extract, total soluble sugars (35.8%) and total phenolics (9.4%). Whereas, Upasana and Deepa (2019) reported that EPP contain crude protein (20.0%) crude fat (2.3%), silica (1.4%), crude fibre (2.3%), brix (7.0%) and carbohydrate (81.1%). Empty pea pods (EPP) and bagasse are mostly available during winter season that may be preserved as silage for animal feeding purpose in lean periods.

MATERIALS AND METHODS

Since, EPP have dry matter content around 15% that is quite low for ensiling. Therefore, in order to preserve EPP as a silage, well dried crop residues were used for mixing in EPP for bringing dry matter content in fodder material up to 35% because low dry matter silage (<20%) may lead to production of butyric acid, non-acidic or rotten smell and may cause spoilage. To evaluate the proper combination of EPP mixed fodder along with the available crop residues (bagasse and wheat straw) for silage making, a trial was conducted on 19th Feb, 2025 at a cattle feed plant (CFP), Rudrapur, Uttarakhand, India. In total 7 treatment combinations were made to find out best combinations to get good to satisfactory silage quality. In this trial, different treatment combinations, indicators and range values to asses good, satisfactory and average quality of silage are depicted in Table No.1 as suggested by many workers in the past (Tahuk *et al.*, 2020; Jianxin and Jun, 2002). According to treatments, different additives such as dry jaggery powder as a source of carbohydrates, bacterial culture (*Lactobacillus spp*.) & silage savour (organic acid solution as preservative) were used to enhance fermentation process during ensiling process. Silage additives are natural or manufactured products that can be added to or applied onto the crop at harvesting in liquid or solid form to improve the efficiency of silage preservation at different stages from fermentation to feeding.

For ensiling, as per the treatment, with the help of tractor attached front loader, each fodder material lot was properly weighed separately on electronic weighing balance and poured in power operated fodder mixture equipment. For about 10-15 minutes, each treatment was properly mixed till homogeneous quantity of fodder was obtained. Preservative named *"silage savour"* @ 500 ml/ton of fodder material was tank sprayed in mixture directly. Silage culture was dissolved in water (1 gram/ton) and tank sprayed on EPP before mixing with crop residues of wheat straw and bagasse. After proper mixing, as per the treatment, fodder material was poured on silage baler conveyer belt for compression in form of a bale (highly densified fodder material). This bale was then wrapped in many layers of low-density polyethylene (LDPE) material by creating anaerobic conditions in order to start fermentation process in the densified fodder material for silage making (ensiling). These wrapped silage bales were weighed on electronic balance and marked with date of ensiling, treatment ratio, weight and kept for ensiling purpose for 45 days at a safe place. For evaluation of silage treatments 10 different kind of parameters were considered based on physical characteristics *viz.* aroma, colour, texture, fungus and chemical compositions *viz.* pH, moisture %, crude protein %, ether extract %, crude fibre % and acid insoluble ash %. For each physical and chemical parameter, three value ranges were taken into consideration *viz.* optimum, medium and low and 10, 6 and 3 marks were assigned to them, respectively (Table 1). As silage quality cannot be satisfactory evaluated on any one of the physical & chemical parameters, therefore, the integrated evaluation method was adopted. Based on the physical and chemical parameters reading after analysis, marks were allocated and based on total marks scored, silage quality of each treatment was classified into good (81-90 marks), satisfactory (71-80 marks) and average class (less than 71 marks) (Table 2).

After the completion of ensiling period, silage bales were cut opened for evaluation purpose. 2-3 kg samples were drawn from few randomly selected bales and thoroughly mixed to take a representative sample for testing. Physical evaluation of these samples was done immediately by silage experts. For chemical analysis, silage samples were tightly packed in polybags, labelled and sent to NDDB-CALF laboratory, Anand, Gujarat. Thereafter, dry samples were fine grinded (1 mm) for chemical analysis. Amount of nitrogen (N) and crude protein content was estimated by using IS/ISO 5983-2 (2005). Proximate analysis was carried out following the standard laboratory procedures (AOAC, 2012). Degree of acidity (pH) was measured by digital precise pH metre.

RESULTS AND DISCUSSION

pH: Degree of acidity (pH) is a good indicator of silage quality due to production of lactic acid in silage. In different treatments, optimum level (3.6-

4.0) of pH was observed in T1, T2 and T3 treatments consisting of empty pea pods (EPP): wheat straw (WS): dry jaggery (WJ) in different proportions (Table 2). Whereas satisfactory level (4.1-4.4) of pH was found in T6 and T7 treatments. Treatments no. T4 and T5 showed average value of pH in silage. Differences in pH may be due to effect of different treatment combinations and its effect on lactic acid production in the silage.

Moisture content (MC): MC plays an important role in determining quality of silage as optimum level of moisture content is needed in ensiled material to activate lactic acid fermentation process. In this trial, optimum level of moisture content (60-70%) was observed T1, T2 and T3 treatments consisting of EPP + wheat straw + dry jaggery mixed silage. In treatments consisting of EPP + bagasse + dry jaggery mixed silage only T4 treatment (68.13%) showed optimum level of moisture content, however, in case of T5, T6 and T7 treatments moisture content was found to be at satisfactory level (70-80%). Variation in MC may be due to the difference in moisture content of crop residues and it may have resulted in less production of lactic acid, due to which pH of these treatments was found to be more in comparison to T1, T2 and T3 treatments.

Crude Protein (CP): This is the total percent of protein in a silage sample. It includes true protein and non-protein nitrogen (N) such as urea N or ammonia N. Optimum CP content (over 10%) was recorded in silage of T1 (11.01%), T3 (10.39%) and T7 (10.06%) treatments. T5 and T6 treatments recorded satisfactory level of CP content in between 8.0 to 10.0 %, whereas, average values between 7.0-8.0% were recorded in T2 and T4 treatments. Variation in CP content may be attributed to variation in crop residue combination amongst treatments (Table 2).

Ether Extract (EE): In silage, the ether extract (also known as crude fat) content primarily indicates the greater energy density, as fats provide more than twice the energy of carbohydrates energy value and the presence of fat-soluble vitamins. In this trial, all the treatment combinations were found to be at satisfactory level for EE content with more or less similar readings between 1.00 to 1.12% (Table 2).

Crude Fibre (CF): Crude fibre is a measure of the indigestible portion of plant material, and as its proportion increases, the overall energy content of the feed decreases. Optimum level (35-45%) of CF content was observed in T1 and T3 treatments, whereas, satisfactory level (45-55%) of CF content was recorded in T2, T5 and T7 treatments and average level (55-65%) of CF content was found in T4 and T6 treatments. Variation in CF content may be due to variation in fodder combinations. In silage, a higher crude fibre (CF) content generally indicates lower digestibility and energy value for livestock.

Acid Insoluble Ash (AIA): AIA represents the silica and other indigestible mineral content in the silage, and a high level negatively impacts digestibility

TABLE 1

Physical characteristics and chemical compositions evaluation ranges/values in silage for quality determination.

Parameter	pH	Moisture (%)	Crude protein (CP) %	Ether extract (EE) %	Crude fibre (CF) %	Acid insoluble Ash %	Aroma	Colour	Texture	fungus
Scoring Marks	10	10	10	10	10	10	10	10	10	10
Optimum range/values	3.6-4.0 (10)	60-70 (10)	Above 10 (10)	Above 1.5 (10)	35-45 (10)	Below 2.0 (10)	Slightly acidic and fruity (10)	Natural green or yellowish green (10)	Solid or dense and non-sticky	None (10)
Medium range/values	4.1-4.4 (6)	70-80 (6)	8-10 (6)	1-1.5 (6)	45-55 (6)	2.0-3.0 (6)	Not acidic (6)	Light green or brownish yellow (6)	Slightly soft and non-sticky (6)	Slightly visible (6)
Average range/values	4.5-4.8 (5)	80-85 (5)	Below 8 (3)	Below 1.0 (3)	55-65 (3)	Above 3.0 (3)	Not rotten (3)	Dark brown (3)	Flabby or mushy and sticky (3)	Lots of visible (3)

TABLE 2
Integrated evaluation of silage samples for quality determination.

Treatment	pH (As such basis)	Moisture % (As such basis)	Crude protein % (Dry basis)	Ether Extract % (Dry basis)	Crude Fibre % (Dry basis)	Acid insoluble Ash % (Dry basis)	Aroma	Colour	Texture	Fungus	Total marks	Overall silage quality
T1 Empty Pea Pod: Wheat Straw: Dry Jaggary (70:29:1) treated with silage preservative. No. of Bales (8), Bales Weight: qtls (3.12)	3.97	65.93	11.02	1.08	43.87	3	Slightly acidic and fruity smell	Light brown	Solid or dense and non-sticky	None		Good
T1 Score Card Marks	10	10	10	6	10	6	10	6	10	10	88	
T2 Empty Pea Pod: Wheat Straw: Dry Jaggary (75:24:1) treated with silage preservative. No. of Bales (9), Bales Weight: qtls (4.82)	3.96	59.45	7.68	1	48.23	2.92	Not acidic	Yellowish green	Solid or dense and non-sticky	None		Satisfactory
T2 Score Card Marks	10	10	3	6	6	6	6	10	10	10	77	
T3 Empty Pea Pod: Wheat Straw: Dry Jaggary (80:19:1) treated with silage preservative. No. of Bales (11), Bales Weight: qtls (4.58)	4	65.86	10.39	1.12	44.17	3.11	Not rotten	Light brown	Solid or dense and non-sticky	None		Satisfactory
T3 Score Card Marks	10	10	10	6	10	3	3	6	10	10	78	
T4 Empty Pea Pod: Sugarcane bagasse: Dry Jaggary (70:29:1) treated with silage preservative. No. of Bales (7), Bales Weight: qtls (4.13)	4.5	68.13	7.17	1	59.85	2.04	Slightly acidic and fruity smell	Light green	Solid or dense and non-sticky	None		Average
T4 Score Card Marks	6	10	3	6	3	6	10	6	10	10	70	
T5 Empty Pea Pod: Sugarcane bagasse: Dry Jaggary (70:29:1) treated with silage Inoculant. No. of Bales (16), Bales Weight qtls (9.34)	4.52	75.68	9.49	1	51.98	1.99	Slightly acidic and fruity smell	Light green	Solid or dense and non-sticky	None		Satisfactory
T5 Score Card Marks	3	6	6	6	6	10	10	6	10	10	73	
T6 Empty Pea Pod: Sugarcane bagasse: Dry Jaggary (75:24:1) with silage preservative No. of Bales (7), Bales Weight: qtls (5.00)	4.39	76.05	9.23	1	61	1.52	Slightly acidic and fruity smell	Yellowish green	Solid or dense and non-sticky	None		Satisfactory
T6 Score Card Marks	6	6	6	6	3	10	10	10	10	10	77	
T7 Empty Pea Pod: Sugarcane bagasse: Dry Jaggary (80:19:1) with silage preservative No. of Bales (7), Bales Weight: qtls (4.35)	4.25	76.55	10.08	1	51.23	1.15	Not rotten	Yellowish green	Flabby/ mushy and sticky texture	None		Average
T7 Score Card Marks	6	6	10	6	6	10	3	10	3	10	70	

*Good quality: 81-90 marks, satisfactory quality: 71-80 marks, average quality: less than 71 marks.

and nutrient utilization by animals. AIA content was observed to be at optimum level (<2%) in T5, T6 and T7 treatments and at satisfactory level (2.0-3.0%) in T1, T2 and T4 treatments. However, in T3 treatment, AIA content was recorded at average level (>3%). Soil contamination of crop residues during harvest or storage is a common cause of elevated AIA. Wheat straw is generally produced in field conditions due to which chances of contamination with soil particles are more during the harvesting, transportation and storage process. In comparison to wheat straw, EPP and bagasse crop residues comes directly from processing factory, therefore, they may contain less soil particles.

Aroma: The aroma of complete silage is one indicator to determine the physical quality that is closely related to the fermentation process. A slightly fruity/sweet, acidic smell may indicate a good fermentation has occurred during ensiling period. Treatments T1, T4, T5 and T6 showed slightly acidic to fruity smell indicating optimum level of lactic acid concentration in silage. whereas not acidic aroma recorded in T2 treatment indicates satisfactory level of lactic acid concentration. T3 and T7 treatments recorded not rotten aroma indicating average levels of lactic acid in silage. Variation in aroma quality may be due to different concentrations of lactic acid or acidic acid in silage.

Colour: Silage colour describes the process of ensiling whether it is running properly or not. Normal colour of complete silage indicates that there was a short respiration in the silo during the ensiling period due to the lack of oxygen trapped in the silo, indicated by yellowish green to light green or brown colour. It also illustrates that the compaction process of the mixture of fodder ingredients in a silage bale was quite adequate. During the process of ensiling period, there should be no excessive or prolonged aerobic respiration that may increase the temperature and cause damage to the silage colour indicated by dark brown to black colour. In this trial, treatments no. T2, T6 and T7 showed yellowish green colour, whereas remaining treatments no. T1, T3, T4 and T6 showed light green or brownish yellow colour indicating optimum to satisfactory readings.

Texture: Good silage has the characteristics of a clear texture like natural material that is solid or dense and non-sticky type. This also indicates good compression of silage ingredients and optimum moisture content in complete silage material. In this trial, all treatments combinations except T7 recorded solid or dense and non-sticky texture indicating optimum range.

Fungus: It is caused due to presence of spoilage microbial activity during fermentation process. Its presence also indicates that lactic acid bacteria are not optimal in inhibiting the activity of spoilage bacteria. Fungal growth in silage indicates spoilage, which can lead to nutrient loss, reduced palatability, and potential health problems for livestock. During the physical examination of silage samples that all treatment combinations were found to be at optimum range as no presence of any fungus was detected (Table 2).

Jianxin and Jun (2002) reported that good quality silage usually has a mild, slightly acidic and fruity smell, resembling that of cut bread and of tobacco (due to the presence of lactic acid), whereas, a rancid and nauseous smell denotes the presence of butyric acid and signifies a failed silage. Based on overall total score card marks, T1 treatment combination of EPP: Wheat straw: Dry Jaggary (70:29:1) was found to be the best combination amongst all 7 treatments combination due to highest marks (88). Silage quality of treatment no. T2, T3 and T6 was found to be of satisfactory quality. However, average quality of silage was found to be in treatment no. T4, T5 and T7.

Animal feeding: To check acceptability of EPP based silage by the animals (palatability), all the bales were distributed to local dairy farmers for feeding to their animals. During this exercise, palatability of silage bales was observed to be satisfactory by field staff of CFP, Rudrapur. To take view of a progressive dairy farmer who was habitual in feeding maize silage and also EPP from factory, about 10 quintals of silage bales of were given to Shri Trilochan Singh from Tada Mahmood Village, Bajpur, Uttarakhand. After feeding, he reported that silage quality of EPP + wheat straw + dry jaggery combination was better in comparison to EPP + bagasse + jaggery due to less moisture content, aroma, colour and texture. In comparison to maize bale silage, he reported similar level of palatability by animals for EPP based silage also due to presence of good aroma, texture as well as by presence pea grains indicating high CP content of silage.

CONCLUSION

It may be summarised that due to the availability of large quantities of Empty pea pods (EPP) from local factories/villages in *Tarai* areas of Uttarakhand, a very good opportunity exists to

conserve these nutrients rich fresh biowaste in combination with wheat straw, sugarcane bagasse and dry jaggery in the ratio of (70:29:1) in form of silage bales during winter season. After completion of 45 days of ensiling period, these silage bales could be supplied to dairy farmers located in fodder deficit areas particularly in hilly districts of Uttarakhand to tackle seasonal fodder deficits. Feeding demonstration of EPP based crop residues silage at farmers level proved that good palatability for animals and acceptability by dairy farmers just like maize silage.

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